

Transceiver Module TCM 410J

20 August 2013



Observe precautions! Electrostatic sensitive devices!

Patent protected:

WO98/36395, DE 100 25 561, DE 101 50 128,
WO 2004/051591, DE 103 01 678 A1, DE 10309334,
WO 04/109236, WO 05/096482, WO 02/095707,
US 6,747,573, US 7,019,241

TCM 410J

REVISION HISTORY

The following major modifications and improvements have been made to the first version of this document:

No	Major Changes
1.00	Initial version
1.10	Added certification information and PCB Design

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Important!

This information describes the type of component and shall not be considered as assured characteristics. No responsibility is assumed for possible omissions or inaccuracies. Circuitry and specifications are subject to change without notice. For the latest product specifications, refer to the EnOcean website: <http://www.enocean.com>.

As far as patents or other rights of third parties are concerned, liability is only assumed for modules, not for the described applications, processes and circuits.

EnOcean does not assume responsibility for use of modules described and limits its liability to the replacement of modules determined to be defective due to workmanship. Devices or systems containing RF components must meet the essential requirements of the local legal authorities.

The modules must not be used in any relation with equipment that supports, directly or indirectly, human health or life or with applications that can result in danger for people, animals or real value.

Components of the modules are considered and should be disposed of as hazardous waste. Local government regulations are to be observed.

Packing: Please use the recycling operators known to you.

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	A.1 Japanese Type Approval	Error! Bookmark not defined.

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1 MODULE VARIANTS AND RELATED DOCUMENTS

This document describes operation of TCM 410J module with the frequency 928.35 MHz. Subject of description is the:

- build in software Gateway Controller.
- used hardware TCM 410J

In the Document we refer to the Hardware and Software characteristic by the module name TCM 410J.

In addition we recommend following our [application notes](#), in particular

- AN101: Power Supply Layout – Layout considerations for Line-Power
- AN102: Antenna Basics – Basic Antenna Design Considerations for EnOcean based Products

The specification of the serial protocol ESP3 can be found here:

<http://www.enocean.com/esp>

2 GENERAL DESCRIPTION

2.1 Basic functionality

TCM 410J is a SMD mountable radio transmitter module enabling the realization of gateways for EnOcean 928.35 MHz radio systems. It provides a bi-directional radio interface and a bi-directional serial interface. Radio messages are sent transparently through the serial interface in both directions from and to an externally connected host processor or host PC. In addition control commands can be sent from the host, e.g. to configure the repeater functionality or to manage Smart Ack functions. TCM 410J can act as postmaster for up to 15 bi-directional sensors using Smart Ack technology.



Features

- Smart Ack controller functionality
- Transparent radio channel
- Programmable repeater functionality (1 Level)
- ESP3 support (EnOcean Serial Protocol V3)
- API programmable!

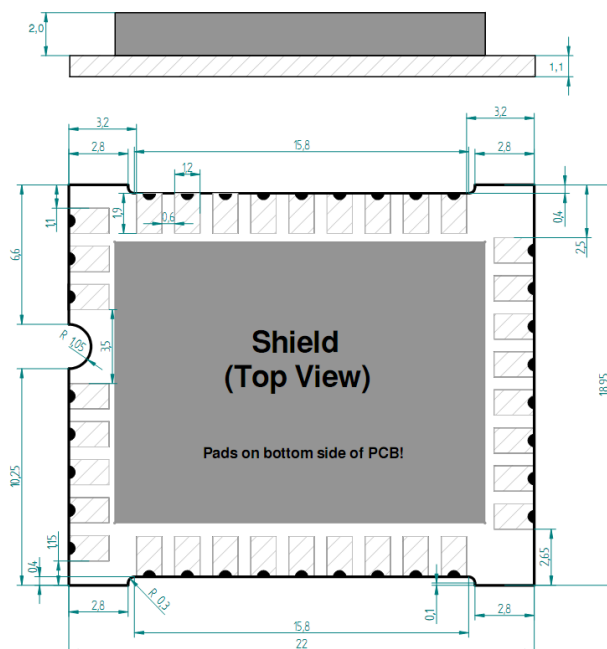
TCM 410J

2.2 Technical data

Features overview

Antenna	External whip or 50Ω antenna mountable
Frequency	928.35 MHz (FSK)
Radio Standard	EnOcean Radio Protocol 2 (FSK)
Data rate/Modulation type	125 kbps FSK
Receiver Sensitivity (at 25°C)	typ. -95 dBm
Conducted Output Power	typ. 0dBm
Power Supply	2.6...5V
Serial Interface	UART - EnOcean Serial Protocol 3
Current Consumption	Receive mode: 27 mA Transmit mode: 22 mA
Dimensions of PCB	22x19x3.1 mm
Operating temperature	-25 to +85°C
Radio Regulations	ARIB STD-T108

2.3 Physical dimensions



Unless otherwise specified dimensions are in mm.

Tolerances:

PCB outline dimensions ± 0.2 mm

All other tolerances ± 0.1 mm

TCM 410J (pads on bottom side of PCB!)

PCB Dimension	22 x 19 x 3.1 mm
Weight	1.9 g

TCM 410J

2.4 Environmental conditions

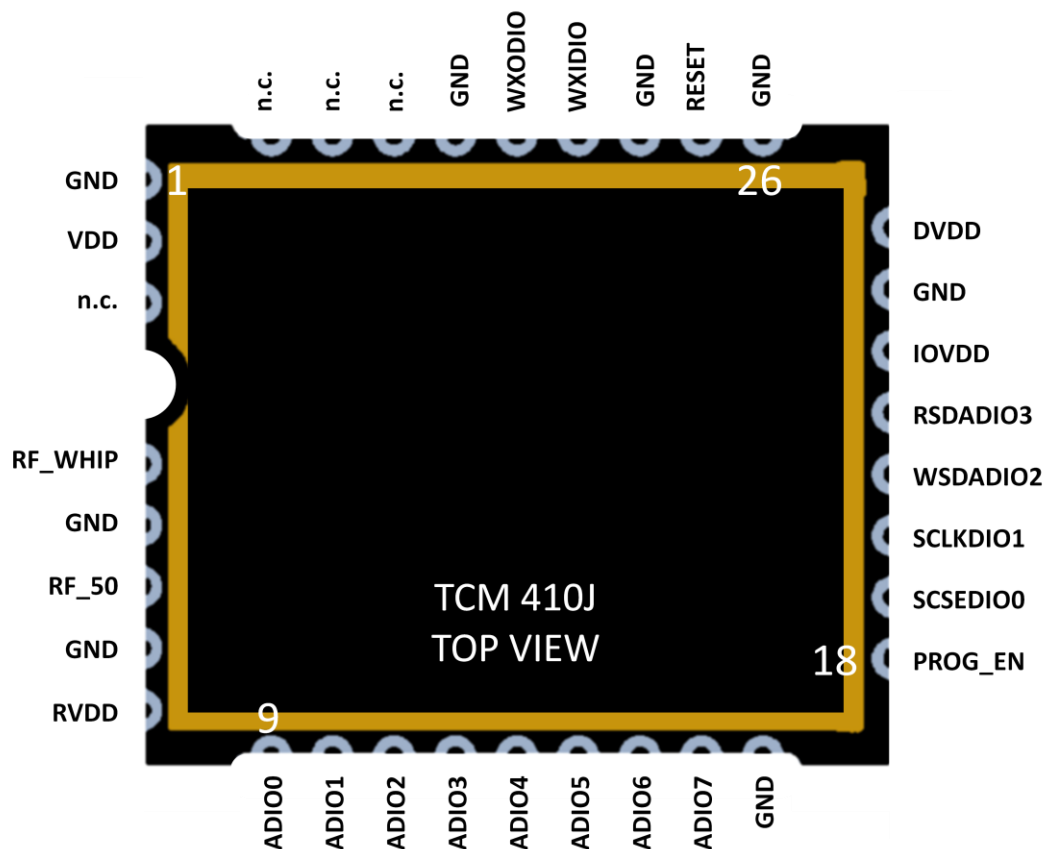
Operating temperature	-25 °C ... +85 °C
Storage temperature	-40 °C ... +85 °C
Storage temperature in tape & reel package	-20 °C ... +50 °C
Humidity	0% ... 93% r.H., non-condensing

2.5 Ordering information

Type	Ordering Code	Frequency
TCM 410J	S3063-K410	928.35 MHz

3 FUNCTIONAL DESCRIPTION

3.1 Pin out



The figure above shows the pin out of the TCM 410J hardware. The pins are named according to the naming of the Dolphin chip to simplify usage of the DOLPHIN API 2.

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The table in section 0 shows the translation of hardware pins to a naming that fits the functionality of the built-in firmware..

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3.2 Pin description and operational characteristics

HW Symbol	Pin #	Function	Characteristics
GND	1, 5, 7, 17, 18, 24, 26, 28, 31	Ground connection	Must be connected to GND; see 4.4
VDD	2	Supply voltage	2.6 V ... 5 V
RVDD	8	RF supply voltage regulator output	Leave open
DVDD	25	Digital supply voltage regulator output	1.8 V Output current: max. 5 mA
IOVDD	23	GPIO supply voltage	Must be connected to desired interface supply voltage (see 3.4) See also 3.2.1.
RESET	27	Reset input	External 10 kΩ pull-down required.
SER_RX – ADIO6	15	UART input	See 3.6
SER_TX – ADIO7	16	UART output	See 3.6
RF_WHIP	4	RF output	Output for whip antenna
RF_50	6	RF output	50 Ohm output for external antenna
n.c.	3, 9-14, 19-22, 29,30, 32-34	Not connected	Do not connect!

3.2.1 GPIO supply voltage - IOVDD

For digital communication with other circuitry (peripherals) the digital I/O configured pins of the mixed signal sensor interface (ADIO0 to ADIO7) and the pins of the serial interface (SCSEDIO0, SCLKDIO1, WSDADIO2, RSDADIO3) may be operated from supply voltages different from DVDD. Therefore an interface voltage supply pin IOVDD is available which must be connected either to DVDD or to an external supply within the tolerated voltage range of IOVDD.



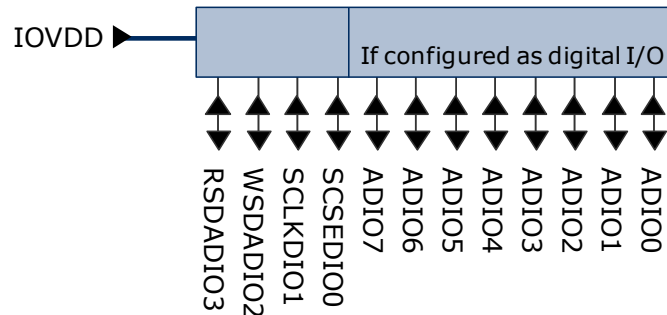
If DVDD=0 V (e.g. in any sleep mode or if $VDD < V_{OFF}$) and IOVDD is supplied, there may be unpredictable and varying current from IOVDD caused by internal floating nodes. It must be taken care that the current into IOVDD does not exceed 10 mA while DVDD=0 V.

If DVDD=0 V and IOVDD is not supplied, do not apply voltage to any above mentioned pin. This may lead to unpredictable malfunction of the device.



For I/O pins configured as analogue pins the IOVDD voltage level is not relevant! However it is important to connect IOVDD to a supply voltage as specified in 3.4.

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3.3 Absolute maximum ratings (non operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD	-0.5	5.5	V
IOVDD	GPIO supply voltage	-0.5	3.6	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	-0.5	2	V
VIND1	Voltage at RESET, and every digital input pin except WXIDIO/WXODIO	-0.5	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	-0.5	2	V

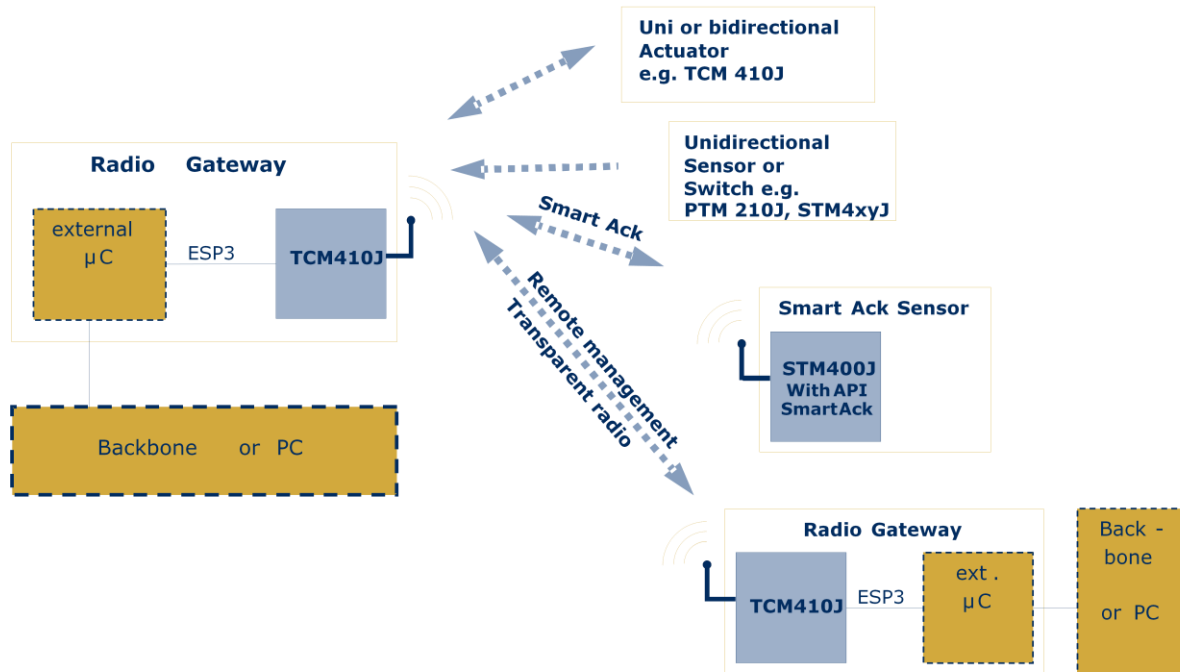
3.4 Maximum ratings (operating)

Symbol	Parameter	Min	Max	Units
VDD	Supply voltage at VDD	2.6	5	V
IOVDD	GPIO supply voltage (see also 3.2.1)	1.7	3.6	V
GND	Ground connection	0	0	V
VINA	Voltage at every analog input pin	0	2.0	V
VIND1	Voltage at RESET, and every digital input pin except WXIDIO / WXODIO	0	3.6	V
VIND2	Voltage at WXIDIO / WXODIO input pin	0	2.0	V
VDDR	Max. ripple at VDD		50	mVpp

3.5 System environment

In the figure below, TCM 410J is shown in a typical system environment.

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3.6 Serial Interface

TCM 410J provides a bi-directional serial interface which conforms to the EnOcean ESP3 specification. For details regarding ESP3 please refer to the ESP3 specification¹. The data rate on the serial interface is 56.8 kbit/s which is usually interoperable with systems running at 57.6 kbit/s.

Direction	Nominal serial data rate	Tolerance
TX (sent by module)	56888 bit/s (=57600 bit/s - 1.23%)	< 50 ppm
RX (received by module)	56888 bit/s	< 5%

The following ESP3 commands are supported:

- Type 1 Radio command for transparent mode (compatible mode)
- Type 10 Radio command for transparent mode (native mode)
- Type 2 Responses
- Type 4 Event
 - SA_CONFIRM_LEARN to confirm/discard learn in/out
 - CO_READY to indicate wake up from deep sleep initiated by CO_WR_SLEEP
- Type 5 Common commands
 - CO_WR_SLEEP to enter energy saving mode (deep sleep mode)
 - CO_WR_RESET to reset the device
 - CO_RD_VERSION to read SW/HW versions, chip ID etc.
 - CO_WR_BIST to perform flash BIST operation
 - CO_WR_IDBASE to write ID range base number
 - CO_RD_IDBASE to read ID range base number

¹ http://www.enocean.com/en/enOcean_modules/tcm-310/

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- CO_WR_REPEATER to configure repeater functionality
- CO_RD_REPEATER to read repeater state
- CO_WR_FILTER_ADD to add filter to filter list (up to 10 filters are supported)
- CO_WR_FILTER_DEL to delete filter from filter list
- CO_WR_FILTER_DEL_ALL to delete all filter
- CO_WR_FILTER_ENABLE to enable/disable supplied filters
- CO_RD_FILTER to read supplied filters
- CO_WR_WAIT_MATURITY to wait maturity time before returning radio telegrams
- CO_WR_MODE - Sets the gateway transceiver mode, either packet type 01 or packet type 10
- Type 6 Smart Acknowledge commands
 - SA_WR_LEARNMODE to set/reset Smart Acknowledge learn mode
 - SA_RD_LEARNMODE to get learn mode
 - SA_WR_LEARNCONFIRM to add or delete a mailbox of a client
 - SA_WR_RESET to send a reset command to a client
 - SA_RD_LEARNEDCLIENTS to get learned mailboxes/clients
 - SA_WR_POSTMASTER to activate/deactivate post master functionality
- Type 7 Remote Management messages up to 256 Bytes



All configuration values set via ESP3 commands are held in RAM and will therefore be lost after RESET or after a deep sleep phase. Only Smart Ack mailboxes are stored in FLASH and are available also after RESET or a deep sleep phase.



After sending a CO_WR_RESET command, the following CO_READY event indicates wake up reason 06 meaning "A memory request from the CPU core does not correspond to any valid memory location." This is caused by the real reset cause used when CO_WR_RESET will be performed. It is not a SW/HW malfunction.

3.7 Built-in Repeater

TCM 410J provides the option to activate a one or two-level repeater for EnOcean radio telegrams.

1 Level Repeater, If a received telegram is a valid and original (not yet repeated), the telegram is repeated after a random delay.



The repeated telegram is marked as "repeated" by an increased repeater counter.

Configuration of the repeater is done via serial interface commands.

For detailed recommendations regarding the usage of repeaters please refer to our application note [EnOcean Wireless Systems - Installation Notes \(PDF\), 09/2010](#).

3.8 Smart Acknowledge

TCM 410J provides a post master function with 15 mailboxes for sensors using Smart Ack technology. For more information on smart acknowledge please refer to <http://www.enocean.com/en/knowledge-base/>.

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When teaching-in a device using Smart Acknowledge please take care to switch off all TCM 4xyJ devices which are not continuously powered. Otherwise these TCM 4xyJ modules could be declared postmaster. As soon as the power supply is switched off, a postmaster would be missing and Smart Acknowledge would not work any longer!

3.9 Remote Management

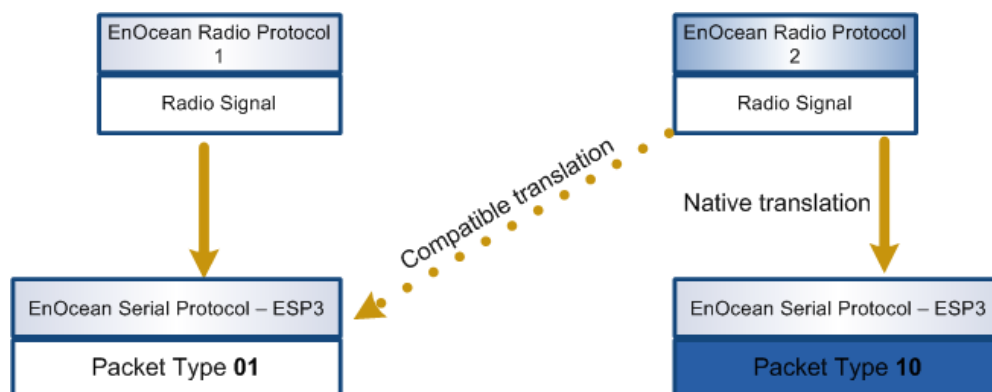
TCM 410J provides a transparent radio channel also for remote management messages with a message length of up to 256 bytes. This enables an external micro controller connected to TCM 410J to handle remote management request from external devices or to control other devices via remote management. For more information on remote management please refer to <http://www.enocean.com/en/knowledge-base/>.

3.10 Serial communication with TYPE 01 or TYPE 10

TCM 410J operates as transparent gateway so the received radio telegrams are forwarded on as serial packets to external controller with type 01 or type 10. The mode can be switched by the serial command CO_WR_MODE.

- Usage of Type 01 is for compatibility reasons (compatibility mode)
- Usage of Type 10 is native for the Radio Protocol of TCM 410J.

The scenario is depicted on the figure below.



For transmission requests from external controller to the TCM 410J both types can be used at any time of the operation.

3.11 Module configuration

Configuration parameters will be stored in a non-volatile memory on the TCM 410J module. The parameters will be changeable with the Dolphin Suite configuration. The following parameters will be adjustable:

- default mode selection – if serial message are forwarded with serial type 01 or serial type 10
- sniffer mode selection – puts module into sniffer mode, which is suiting for network observation and evaluation
- baud rate selection

4 APPLICATIONS INFORMATION

4.1 Transmission range

The main factors that influence the system transmission range are type and location of the antennas of the receiver and the transmitter, type of terrain and degree of obstruction of the link path, sources of interference affecting the receiver, and “dead” spots caused by signal reflections from nearby conductive objects. Since the expected transmission range strongly depends on this system conditions, range tests should categorically be performed before notification of a particular range that will be attainable by a certain application.

The following figures for expected transmission range are considered by using a PTM, a STM or a TCM radio transmitter device and the TCM radio receiver device with preinstalled whip antenna and may be used as a rough guide only:

- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Plasterboard walls / dry wood: Typically 30 m range, through max. 5 walls
- Ferro concrete walls / ceilings: Typically 10 m range, through max. 1 ceiling
- Fire-safety walls, elevator shafts, staircases and supply areas should be considered as screening.

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided. Other factors restricting transmission range:

- Devices mounted on metal surfaces (shielding and detuning of antenna may cause heavy loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- Suspended ceilings with panels of metal or carbon fibre
- Lead glass or glass with metal coating, steel furniture

The distance between EnOcean receivers and other transmitting devices such as computers, audio and video equipment that also emit high-frequency signals should be at least 0.5 m

A summarized application note to determine the transmission range within buildings is available as download from www.enocean.com.

4.2 Antenna options

4.2.1 Overview

Several antenna types have been investigated by EnOcean. Please refer to our application notes AN102, and AN105 which give an overview on our recommendations.

4.2.2 Whip antenna

928.35 MHz

Antenna: 64 mm wire, connect to RF_WHIP

Minimum GND plane: 50 mm x 50 mm

Minimum distance space: 10 mm

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Positioning and choice of receiver and transmitter antennas are the most important factors in determining system transmission range.

For good receiver performance, great care must be taken about the space immediately around the antenna since this has a strong influence on screening and detuning the antenna. The antenna should be drawn out as far as possible and must never be cut off. Mainly the far end of the wire should be mounted as far away as possible (at least 15 mm) from all metal parts, ground planes, PCB strip lines and fast logic components (e.g. micro-processors).

Do not roll up or twist the whip antenna!

Radio frequency hash from the motherboard desensitizes the receiver. Therefore:

- PCB strip lines on the user board should be designed as short as possible
- A PCB ground plane layer with sufficient ground vias is strongly recommended

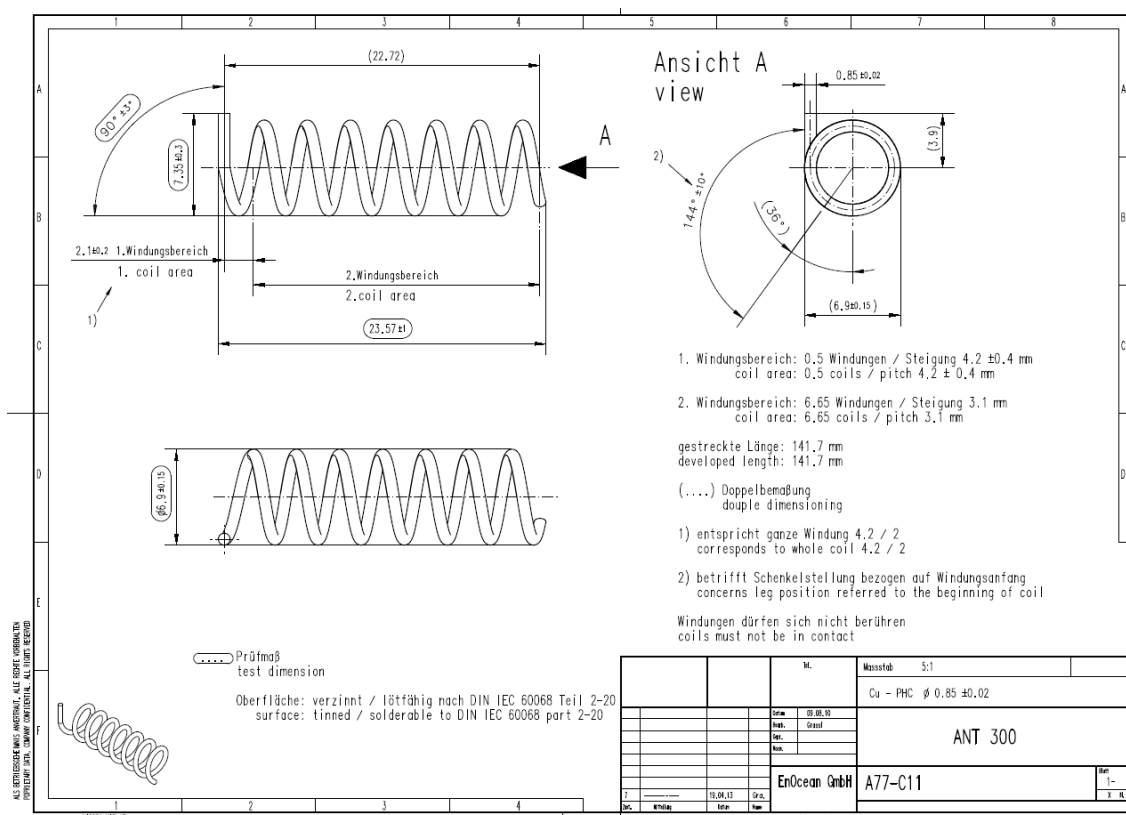
4.2.3 Helical antenna

928.35 MHz

according to drawing below, connect to RF_WHIP

Minimum GND plane: 35 mm x 30 mm

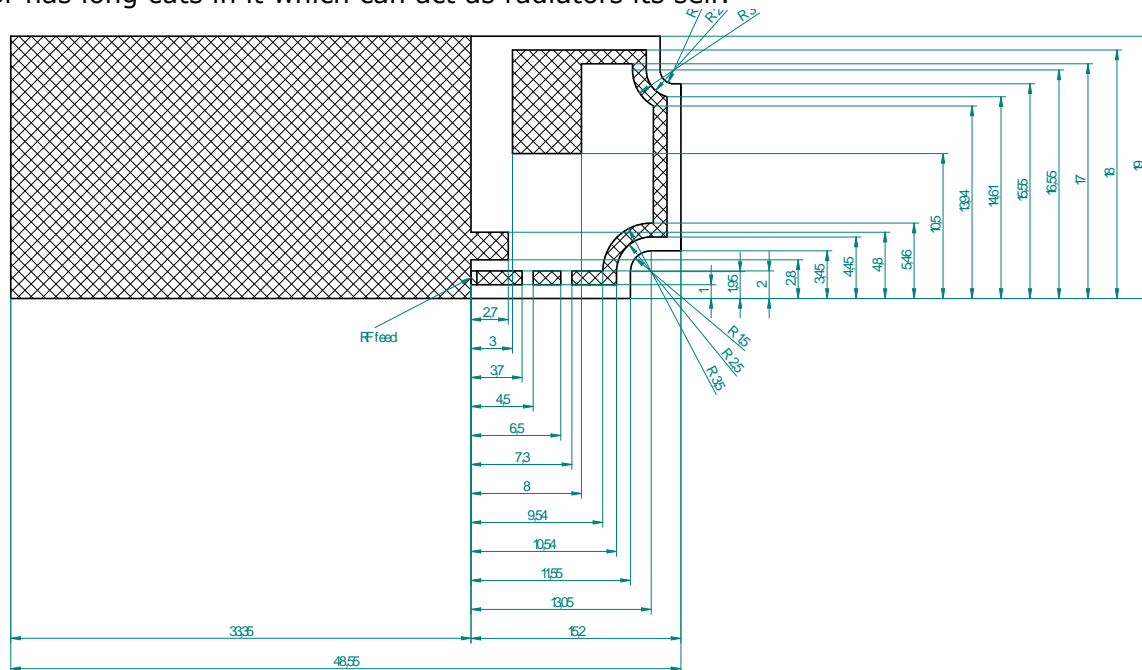
Minimum distance space: 10 mm



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4.2.4 Top loaded PCB spiral antenna

The design of the antenna made on a 1mm thick, two layer FR4 PCB. The dimensions are given in figure below. The hatched areas are double sided in layout. The large area to the left is a ground area. Components can be placed here as long as the area is not split by this nor has long cuts in it which can act as radiators its self.



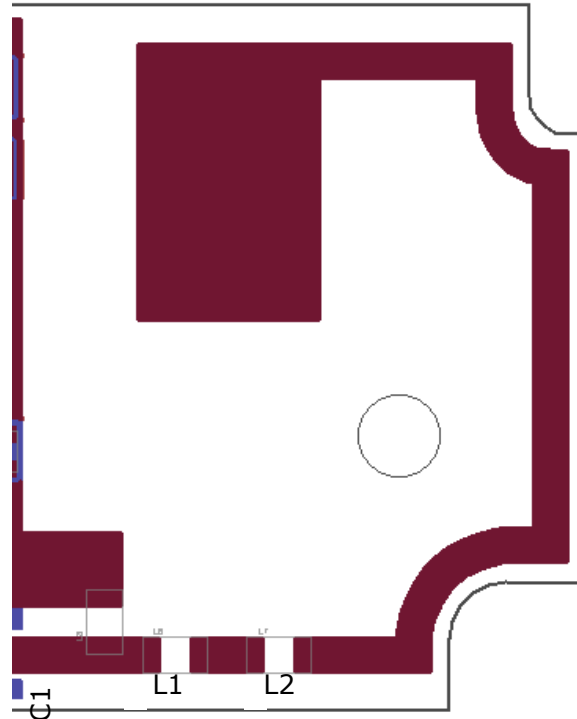
Dimensions of the PCB antenna.

Parameter of PCB	VALUE
PCB material	FR4, 2 layer
Thickness (total)	1,27mm
Shape	Rectangular with millings
Dimension	19*48,55 mm

Layer	Thickness in μm	Exact description
Solder Mask		Solder resist
Top Layer	35	Cu, >35um after electroplating
Core	1200	
Bottom Layer	35	Cu, >35um after electroplating
Solder Mask		Solder resist
Total	1270	

The PCB antenna uses three discrete matching components. The position of these components can be seen in figure below.

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**Position of matching components**

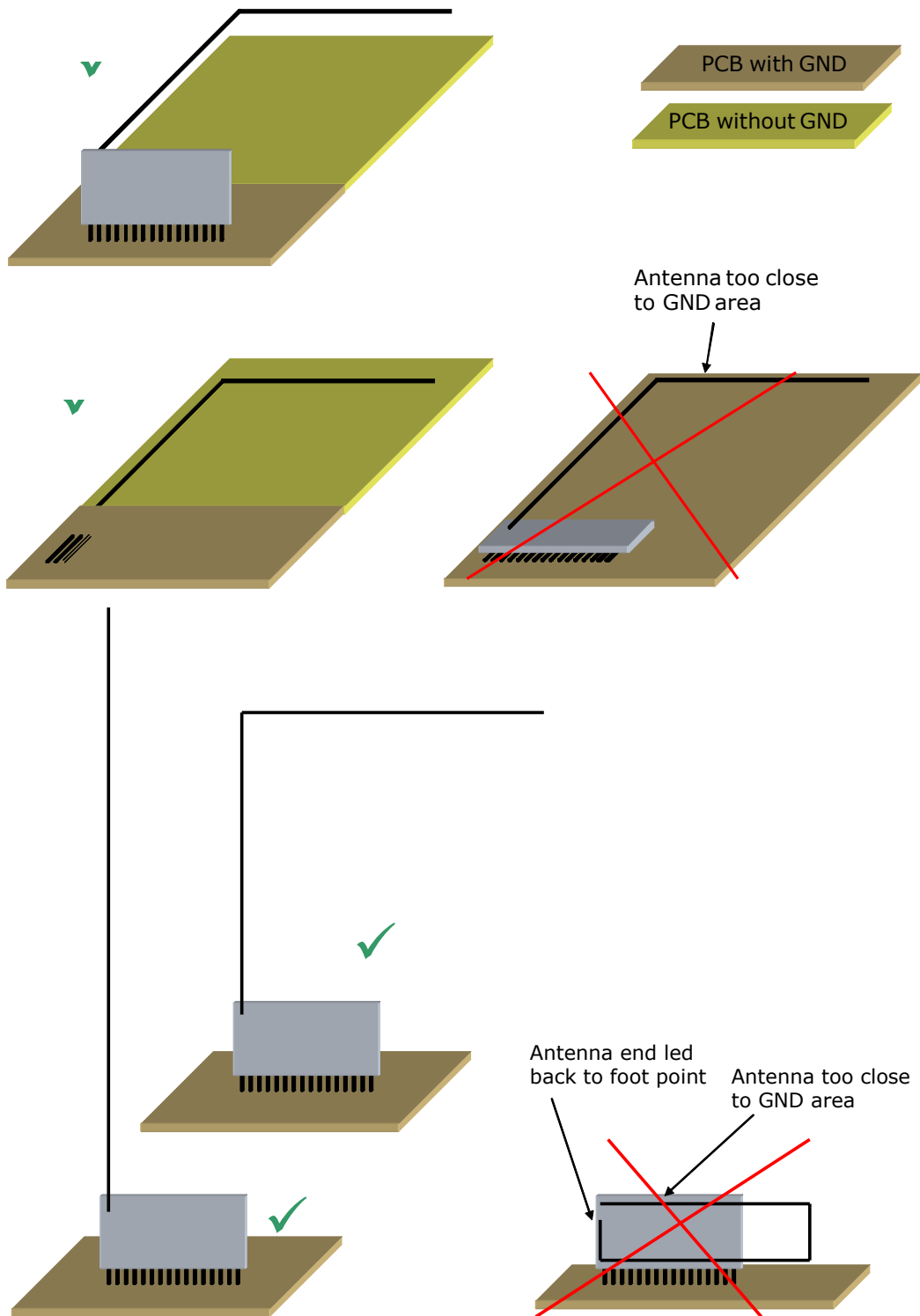
The antenna was matched to 50 Ω input impedance at the feed point. A compromise for a good matching when plugged into a laptop and when plugged to the end of a USB cable was chosen. Several environments in the proximity of the antenna were also evaluated for this compromise. The following table shows the values of the proposed components.

Component	Value
C1	3.3pF
L1	12nH
L2	12nH

0603 components were used for the antenna matching. For the capacitor general purpose COG capacitors with 5% tolerance are sufficient. The inductors should be wire wound inductors from the Würth WE-KI series or the Murata LQW series.

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4.3 Recommendations for laying a whip antenna



4.4 Power supply requirements

In order to provide a good radio performance, great attention must be paid to the power supply and a correct layout and shielding. It is recommended to place a 22 μ F ceramic capacitor between VDD and GND close to the module (material: X5R, X7R, min 6.3 V to avoid derating effects). In addition a 470 nH coil shall be inserted (Murata LQW18A, 0603) in the power supply line.

For best performance it is recommended to keep the ripple on the power supply rail below 10 mVpp (see 3.4).



All GND pins must be connected to GND. Be careful not to create loops! The ground must be realized ideally on both sides of the PCB board with many vias. At least there must be a short star connection. Otherwise RF performance can be reduced!

4.5 Layout recommendations



The length of lines connected to I/Os should not exceed 5 cm.



It is recommended to have a complete GND layer in the application PCB, at least in the area below the module and directly connected components (e.g. mid-layer of your application PCB).

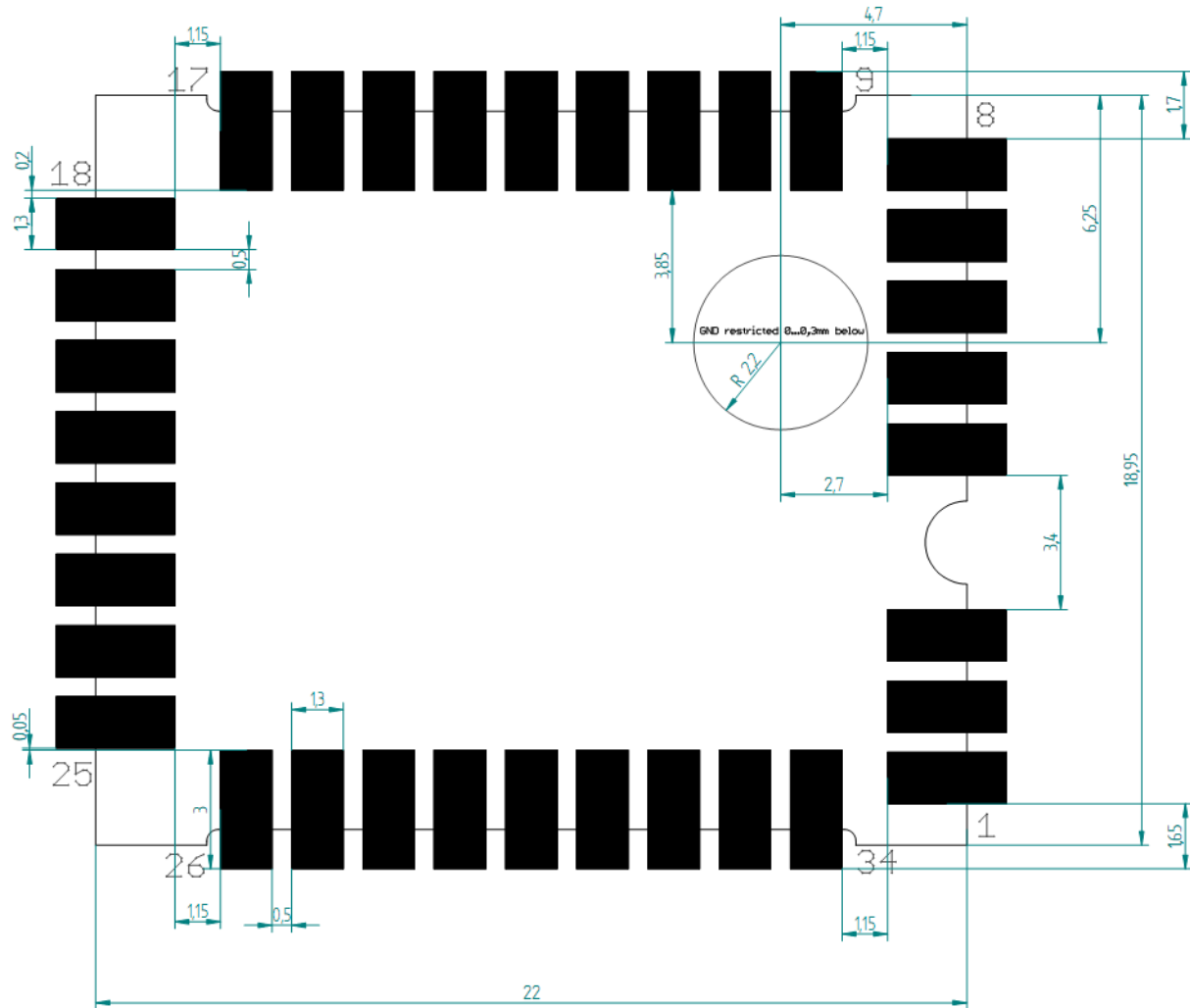
Due to unisolated test points there are live signals accessible on the bottom side of the module.

Please follow the following advices to prevent interference with your application circuit:

- We suggest avoiding any copper structure in the area directly underneath the module (top-layer layout of your application PCB). If this is not possible in your design, please provide coating on top of your PCB to prevent short circuits to the module. All bare metal surfaces including vias have to be covered (e.g. adequate layout of solder resist).
- It is mandatory that the area marked by the circle in the figure below is kept clear of any conductive structures in the top layer and 0.3 mm below. Otherwise RF performance will be degraded!

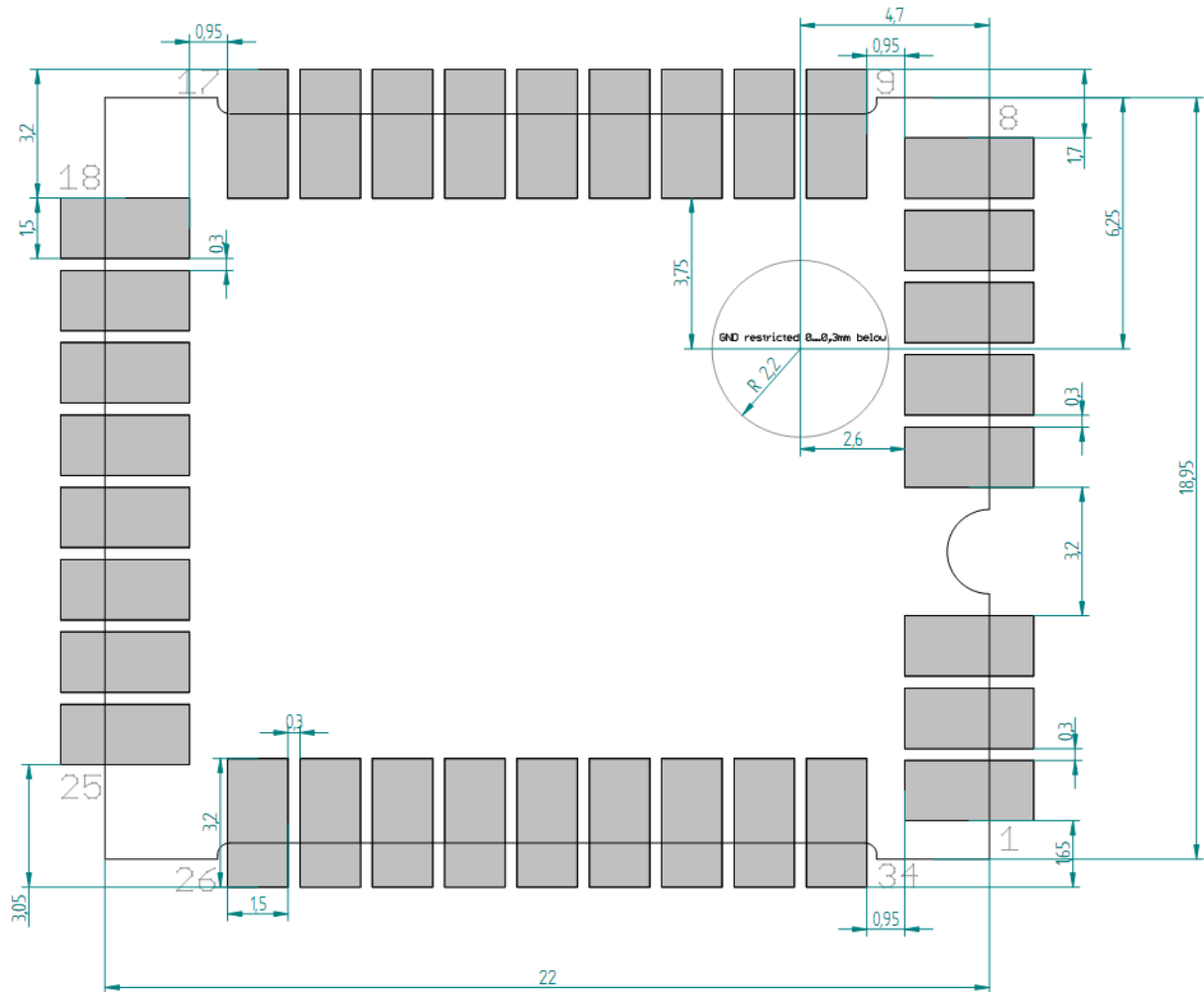
Furthermore, any distortive signals (e.g. bus signals or power lines) should not be routed underneath the module. If such signals are present in your design, we suggest separating them by using a ground plane between module and these signal lines.

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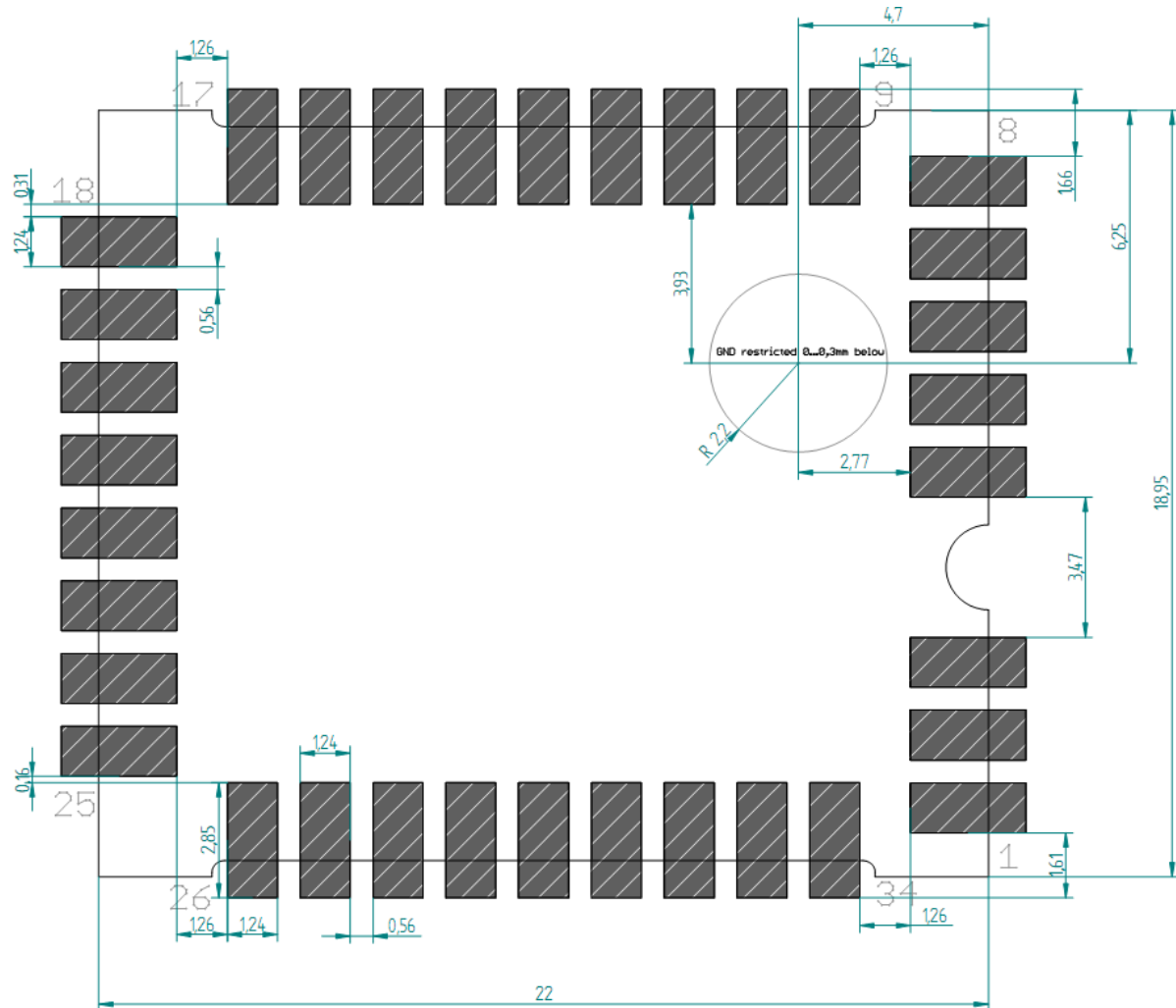
4.5.1 Recommended foot pattern**Top layer**

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Solder resist top layer



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Solder paste top layer

The data above are also available as EAGLE library.

In order to ensure good solder quality a solder mask thickness of 150 µm is recommended.

In case a 120 µm solder mask is used, it is recommended to enlarge the solder print. The pads on the solder print should then be 0.1 mm larger than the pad dimensions of the module as specified in chapter 0. (not relative to the above drawing).

Nevertheless an application and production specific test regarding the amount of soldering paste should be performed to find optimum parameters.

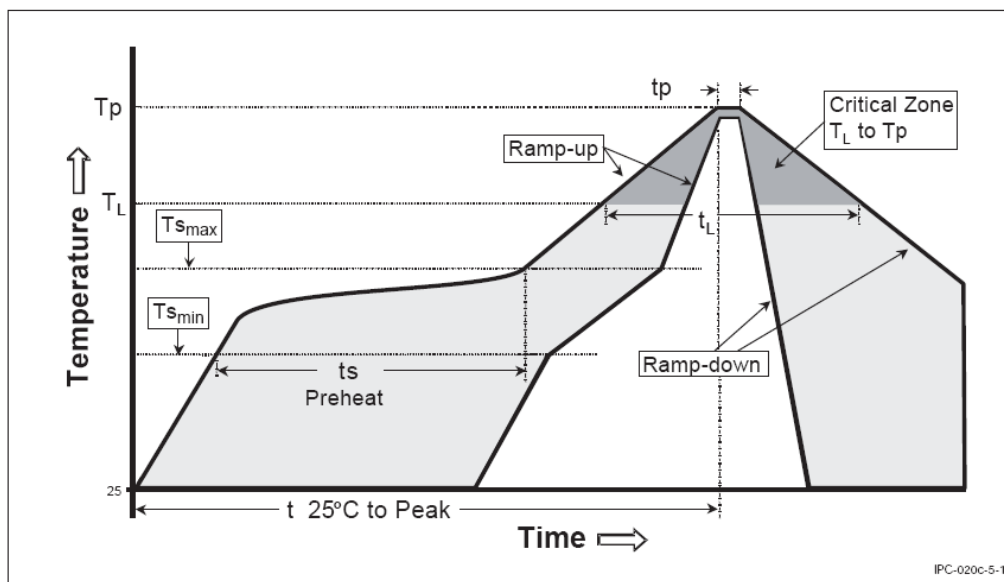
TCM 410J

4.6 Soldering information

TCM 410J shall be soldered according to IPC/JEDEC J-STD-020C standard.

Profile Feature	Pb-Free Assembly
Average Ramp-Up Rate ($T_{s_{max}}$ to T_p)	3° C/second max.
Preheat	
– Temperature Min ($T_{s_{min}}$)	150 °C
– Temperature Max ($T_{s_{max}}$)	200 °C
– Time ($t_{s_{min}}$ to $t_{s_{max}}$)	60-180 seconds
Time maintained above:	
– Temperature (T_L)	217 °C
– Time (t_L)	60-150 seconds
Peak/Classification Temperature (T_p)	260 °C
Time within 5 °C of actual Peak Temperature (t_p)	20-40 seconds
Ramp-Down Rate	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.



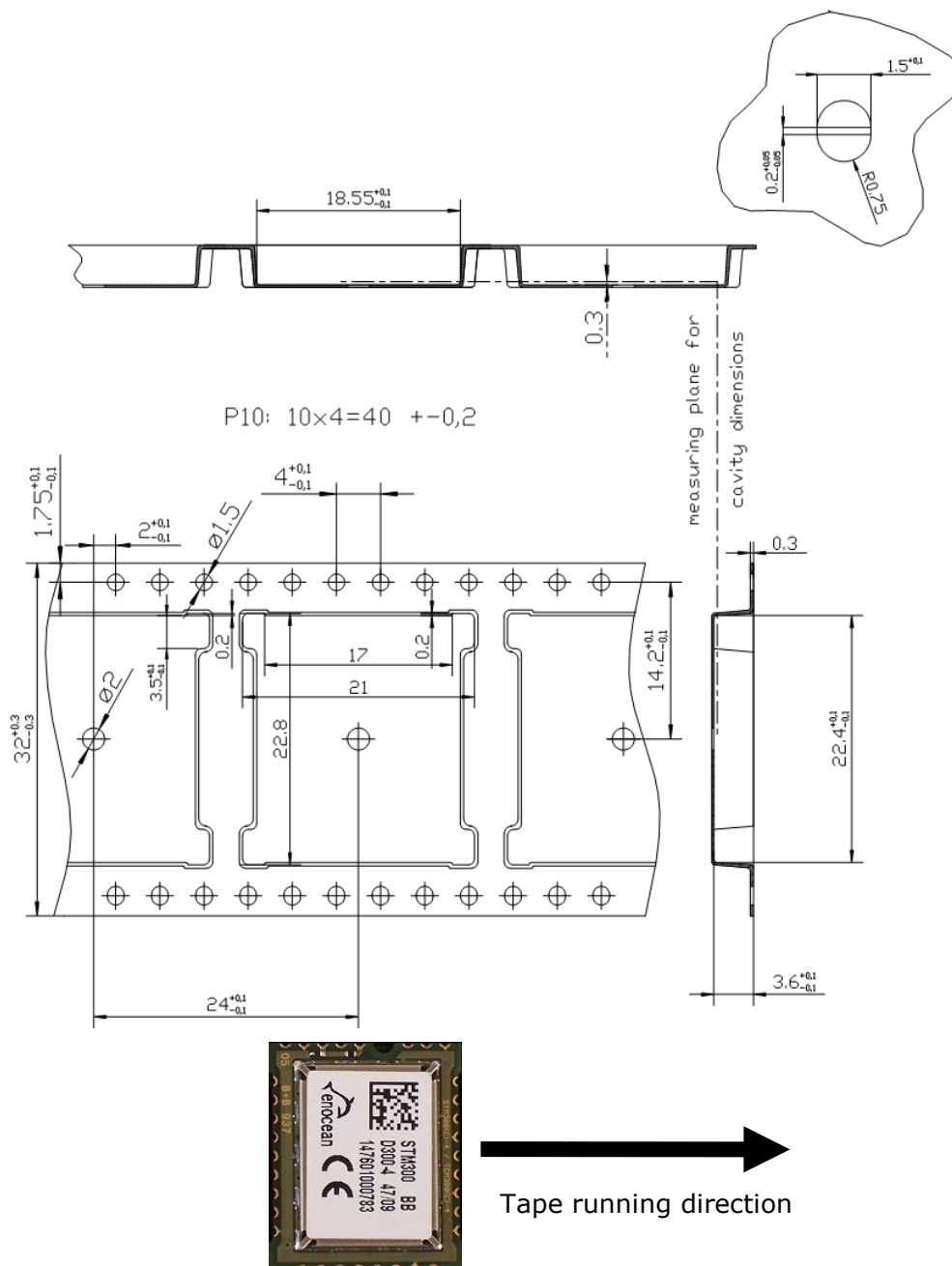
TCM 410J shall be handled according to Moisture Sensitivity Level MSL4 which means a floor time of 72 h. TCM 410J may be soldered only once, since one time is already consumed at production of the module itself.

Once the dry pack bag is opened, the desired quantity of units should be removed and the bag resealed within two hours. If the bag is left open longer than 30 minutes the desiccant should be replaced with dry desiccant. If devices have exceeded the specified floor life time of 72 h, they may be baked according IPC/JEDEC J-STD-033B at max. 90°C for less than 60 h.

Devices packaged in moisture-proof packaging should be stored in ambient conditions not exceeding temperatures of 40 °C or humidity levels of 90% r.H.

TCM 410J modules shall be soldered within 6 months after delivery!

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4.7 Tape & Reel specification

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5 AGENCY CERTIFICATIONS

The modules have been tested to fulfil the approval requirements based on the built-in firmware.



When developing customer specific firmware based on the API for this module, special care must be taken not to exceed the specified regulatory limits, e.g. the duty cycle limitations!

5.1 Japanese Type Approval

TCM 410J complies with the Japanese radio law and is certified according to ARIB STD-T108.

When the product is placed on the Japanese market, it must carry the Specified Radio Equipment marking as shown below:



If the certification label cannot be recognized from outside (e.g. installation in a host) appropriate information must be referenced in the user manual.



Notified Body Directive 99/5/EC
 Notified Body EMC Directive 2004/108/EC
 RF CAB under the Japan-EC MRA
 PCB under the Canada-EC MRA
 TCB under the USA-EC MRA
 RF CAB ID No. 206

Annex to Certificate Registration No. JU000372D
 Date 2013-08-09
 Page 1 of 1

Designated by the German Regulator Bundesnetzagentur to act as a
 Recognised Foreign Conformity Assessment Body in accordance with the Japan-EC MRA

CONSTRUCTION TYPE CONFORMITY CERTIFICATE for Specified Radio Equipment

Registration No. JU000372D
 Certificate Holder EnOcean GmbH
 Kolpingring 18a
 82041 Oberhaching
 Germany
 Product Category Article 2, Paragraph 1, Item 8 (Y)
 Product Designation STM 400J, TCM 410J, USB 400J
 Product Description Scavenger Transceiver Module, Transceiver Module, USB Gateway
 Software Release No. —
 Manufacturer Katek GmbH
 Bahnhofstraße 108
 83224 Grassau
 Germany

When the product is placed on the
 Japanese market, it must carry the
 Specified Radio Equipment marking
 as shown on the right



The scope of evaluation relates to the submitted documents only.

This Certificate confirms that the listed product has demonstrated conformity with the relevant
 technical regulations defined in the attached Annex. It is only valid in conjunction with the Annex.

Unterzeichner:
 2013-08-09


 Klaus Knörig
 Recognised Foreign Conformity Assessment Body

EMCCert DR. RAŠEK GmbH • Störmhofer Berg 15, 91364 Unterwiesenthal, Germany
 Tel.: +49-9194-72279-01 • Fax: +49-9194-72279-06 • E-mail: emcc.cert@emcc.de • Web: www.emcc.de

Technical Construction File (TCF) Details

Technical Standards and Specifications

The product complies with:

Ordinance Regulating Radio Equipment (Radio Regulatory commission No.18, 1950)
 Chapter I General Provisions
 Chapter II Transmitting Equipment
 Chapter III Receiving Equipment
 Chapter IV Article 49.14

Documentation submitted for the Type Certification

Test Report No. EMCC-110010CC Issue Date 2013-07-10 Issued by EMCCcons DR. RAŠEK GmbH & Co. KG

Product documentation
 Antenna specifications
 Block diagram
 Component layout
 Internal & external photographs
 Label sample
 Schematic diagrams
 User manual

Quality System documentation
 ISO 9001 Certificate for manufacturer

Technical characteristics

Type of modulation: FSK
 Emission designator: F1D
 Operating frequency range: 928.35 MHz
 Rated transmitter output power: 1 mW
 Maximum antenna gain: 2.15 dBi

Other information

The device is certified for operation with the following antenna(s):
 ANT 300, helical antenna, 2.15 dBi gain
 Whip antenna, 64mm, -3.89 dBi gain
 USB 400J, top loaded PCB spiral antenna, 1.14 dBi gain

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